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Guideline on Exceptions to Data Requirements for Determining Attainment of Particulate Matter Standards

Systems Applications, Inc., San Rafael, CA

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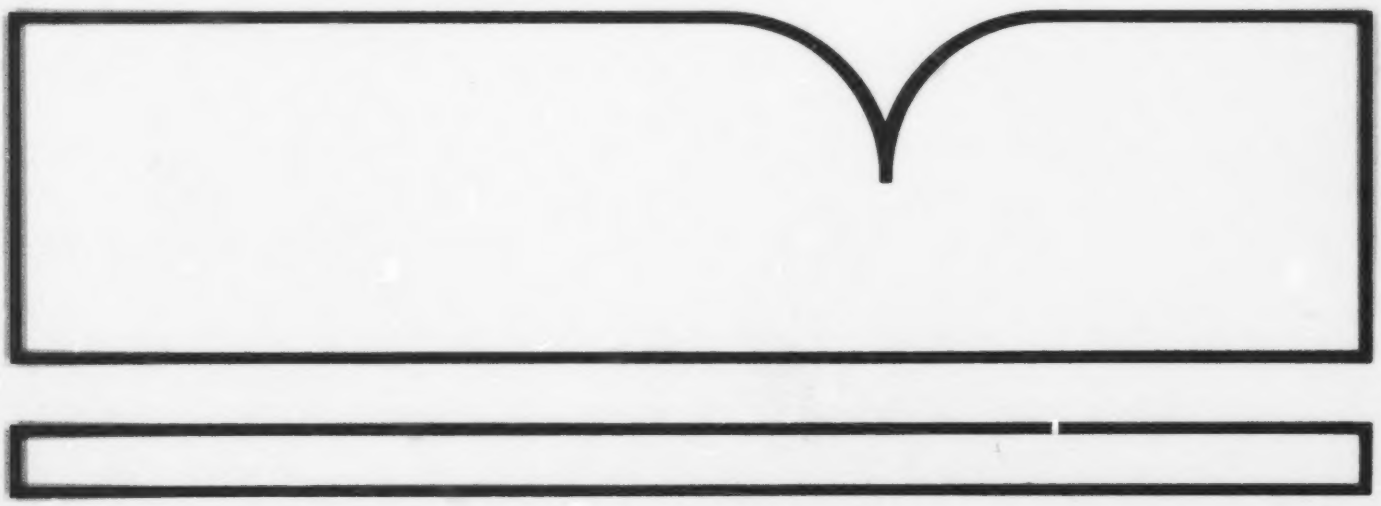

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Office of Air Quality Planning and Standards
Monitoring and Data Analysis Division
Research Triangle Park NC 27711

PREFACE

This report has been reviewed by the Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency and approved for publication. Any mention of trade names or commercial products is not intended to constitute endorsement or recommendation for use.

The report was prepared by Systems Applications, Inc. (SAI) of San Rafael, California under EPA Contracts 68-02-3848 and 68-02-4335.

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ABSTRACT

This guideline document describes procedures that can be used to demonstrate attainment of the particulate matter standards for those sites that do not satisfy the minimum data requirements. In order to apply these procedures, minimum quarterly data requirements must be met. The procedures involve the substitution of appropriate data for the missing samples; collocated TSP can be substituted for missing PM 10 samples, and substitutions from available monitoring data are also allowed. Under certain conditions, model-derived estimates of annual means and number of exceedances may also be used. Four examples demonstrate the use of the procedures under various scenarios.

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Section 1

INTRODUCTION AND BACKGROUND

The U.S. Environmental Protection Agency (EPA) recently revised the National Ambient Air Quality Standards (NAAQS) for particulate matter (PM). While the former standards for particulate matter were based on total suspended particulates (TSP), the new standards are based on particles with an aerodynamic diameter less than 10 micrometers, hereafter referred to as PM 10.

The former primary particulate matter standards specified that the annual geometric mean TSP concentration at a site was not to exceed 75 $\mu g/m^3$, and that 24-hour TSP concentrations were not to exceed 260 $\mu g/m^3$ more than once per year. The new primary standards, based on PM 10, are statistically based, and should provide more stable objectives for developing emission control strategies because they are expressed as expected annual values (Curran, 1979; Hayes et al., 1983). The expected annual arithmetic mean is not to exceed 50 $\mu g/m^3$, and the expected number of concentrations above 150 $\mu g/m^3$ per year is not to exceed one.

Appendix K to 40 CFR, Part 50: "Interpretation of the National Ambient Air Quality Standards for Particulate Matter," describes the calculation of expected annual average and expected annual exceedances that are used to determine attainment. These calculations are generally to be based on the most recent three calendar years of particulate data. The expected annual average is calculated as the average of the three annual means. The expected number of annual exceedances is calculated as the average of the number of exceedances for each of the three years; if data in a given year are incomplete, but meet the minimum requirements specified in Appendix K, the annual exceedance rate is estimated from the observed exceedance rate.

The required sampling frequency for PM 10 the first year is one 24-hour sample every six days, every two days, or every day, depending on the probability of nonattainment of the PM 10 standards; for subsequent years the sampling frequency will depend on site attainment status, as described in 40 CFR 58.13. However, the EPA recognizes that data from some scheduled sampling days may be missing for any of a number of reasons, e.g., damaged filters (sample loss), miscalibrated equipment, or other equipment failure. Appendix K specifies a minimum 75 percent data capture rate* of required PM10 samples, but states that: "Data not meeting these criteria may also suffice to show attainment, however, such exceptions will have to be approved by the Regional Administrator in accordance with established guidelines."

The present document is intended to provide guidance for such exceptions to the data requirements, but it is not intended to list all possible situations in which data may be acceptable; other procedures besides those described in this guideline may be used to determine attainment of the particulate matter standards, if approved by the Regional Administrator. Eligibility requirements for the use of these guidelines are given in Section 2. Section 3 describes specific procedures that may be used to determine attainment status of the 24-hour and annual standards; and examples of the application of these procedures are given in Section 4.

These guidelines were formed with four principles in mind. First, the procedures should be relatively simple and not require elaborate computer programs (except when air quality models are used). Second, the procedures should be conservative, so that there is a low probability of falsely classifying a site as attainment when it is in fact nonattainment. Third, it is assumed that monitoring programs are designed so that, on the average, the data capture rate exceeds the minimum specified in Appendix K and that certain days of the week or seasons of the year are

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* Data capture rate is defined as the number of valid samples as a percentage of the number of scheduled sampling days.

not systematically excluded. These guidelines are not intended to replace Appendix K and become de facto standards. Fourth, the estimated annual number of exceedances and estimated annual average concentrations derived from procedures specified in this guideline shall not be used to establish eligibility for any further adjustments to data in order to demonstrate attainment, such as those permitted by the Guideline on Accounting for Trends in Emission and Air Quality Data (EPA, 1987a).

Section 2

ELIGIBILITY REQUIREMENTS

The procedures described in this document may, under certain conditions, be used to show attainment of the particulate matter standards. As discussed in Appendix K, nonattainment of the standards can also be shown with less than the amount of data required, without using the procedures in this guideline; e.g., if there are four observed exceedances in a single year for a site regardless of sampling frequency.

The EPA has defined the three-year minimum data requirements in Appendix K to correspond to an achievable data capture of 75 percent per calendar quarter. The EPA does recognize, however, that extenuating circumstances can lead to even more missing data. Nevertheless, in order to apply the procedures of this guideline, justification for the missing samples must be provided.

The minimum requirements for use of these guideline procedures are as follows:

(1) If two or more years of monitoring data are available, there must be at least 50 percent of the required samples in each quarter. At least one of the years must indicate attainment based on monitored concentrations that meet the minimum data requirements and follow the round-off conventions in Appendix K.

(2) If only one year of representative PM 10 data with everyday sampling is available, then it may be considered if the data capture rate exceeds 75 percent in each quarter. The procedures

in this guideline cannot be used to demonstrate attainment if there is only one year of data and the data capture rate is below 75 percent in one or more quarters. However, because of the possibility of mid-year startup monitoring, representative data from four consecutive calendar quarters of everyday sampling may be used; in such a case the data capture rate must also be at least 75 percent per quarter.

Section 3

PROCEDURES FOR DETERMINING ATTAINMENT OF THE PARTICULATE MATTER STANDARDS

If the available particulate matter data do not satisfy the minimum three-year data requirements of Appendix K, but do satisfy the less restrictive data requirements described in Section 2 of this document, then any one of the following procedures may be used to demonstrate attainment of the particulate matter standards on the equivalent basis of three years:

(1) If three years of PM 10 data are available and the eligibility requirements of Section 2 of this guideline are met, substitutions may be made for scheduled sampling days with missing particulate matter data. Substitutions must be made for every scheduled sampling day with missing data in each quarter that does not satisfy the minimum data requirements in Appendix K. The substituted value may be one of two kinds of data:

(a) Collocated TSP data may be substituted for missing PM 10 data. If collocated TSP data are available for those scheduled sampling days with missing PM 10 data, and if the number of such days added to the number of days with valid PM 10 data is greater than or equal to the minimum specified in Appendix K, then the TSP data may be used in place of the missing PM 10 data to show attainment, using the calculations of Appendix K. All available TSP data from scheduled sampling days in which there are no valid PM 10 data must be used in the calculation to show attainment.

(b) Monitoring data from the same quarter in any one of the years used to determine attainment may be substituted for missing PM 10 data. The maximum PM 10 (or TSP) value that was observed in that quarter over the attainment test period (e.g., the last three years) may be substituted for missing scheduled sampling days, provided emissions and meteorology for these quarters are representative of the emissions and meteorology for the quarter in question. Data from representative adjacent monitoring sites may be used to substantiate the representativeness of the substituted data.

After substitutions have been made, calculations of annual averages and expected exceedance rates proceed according to Sections 3 and 4 of Appendix K.

(2) Modeling data for an entire year may be used in place of monitoring data for a year with missing data, provided that the EPA's Guideline on Air Quality Models (EPA, 1986) has been followed and that the model is one of those listed in EPA's PM 10 SIP Development Guidance (EPA, 1987b). Model-derived estimates of the annual mean and annual exceedance rate can be used in the calculations of expected annual mean and expected annual exceedance rate specified in Appendix K, unless monitoring data show higher values. For the one or two years of available PM 10 data that will be used in conjunction with the modeling data, substitution must be made as described in procedure (1) for any quarters that have data for less than 75 percent of the scheduled sampling days.

(3) Attainment can be determined on the basis of only one or two years of PM 10 data in the absence of modeling data if the following conditions are met:

(a) The eligibility requirements of Section 2 are satisfied.

(b) Emissions and meteorological conditions are consistent in the three years of concern.

(c) PM 10 data are available on sampling days with representative meteorological conditions.

Substitutions must be made in each calendar quarter with less than 75 percent of scheduled samples. The expected annual exceedance rate and annual average can then be calculated using the one or two years of available data (with substitutions, if necessary).

Section 4

EXAMPLES

This section illustrates the use of the procedures described in Section 3. Annual means and exceedance rates are derived for each of three years; the expected annual means are then compared to the annual average PM 10 NAAQS of 50 $\mu g/m^3$, and the expected annual exceedances of the 24-hour average PM 10 standard of 150 $\mu g/m^3$ are examined to determine attainment status. In these examples all concentrations are expressed as $\mu g/m^3$, and the Appendix K rounding conventions are followed.

EXAMPLE I: USE OF COLLOCATED TSP DATA

In this simple case there is just one PM 10 sample less than the number required by Appendix K. Consider a PM 10 monitor on a once-in-six-day schedule with a collocated TSP monitor and three years of data. In the first and third years the annual average PM 10 concentrations are 40.2 and 36.3 $\mu g/m^3$, respectively, and there are no observed exceedances of the 24-hour standard. In the third quarter of the second year (see Table 1) only 11 samples were obtained from the 16 scheduled sampling days, one less than the 12 per quarter required by Appendix K. The average PM 10 concentration of the 11 samples is 38.1 $\mu g/m^3$. Suppose that collocated TSP 24-hour averages of 97, 65, and 134 $\mu g/m^3$ are available for only three of the five days with missing PM 10 averages. These three TSP samples, combined with the 11 PM 10 samples, constitute a valid quarter (consisting of 14 samples) and can therefore be used to demonstrate attainment. The third quarter average of the second year would then be calculated as

TABLE 1. Quarterly PM 10 statistics for the second year in Examples I, II, and III (all concentrations are in $\mu g/m^3$).

Quarter	Number of Samples	Quarterly Average* $\bar{x}_q$
1	14	41.6
2	13	39.9
3	11	38.1
4	15	43.3

* Calculated from available PM 10 concentrations.

Annual averages for first and third years, are, respectively,

$\bar{y}_1 = 40.2\ \mu g/m^3$

$\bar{y}_3 = 36.3\ \mu g/m^3$

$$\bar{x}_3 = \frac{(11 \times 38.1) + 97 + 65 + 134}{11 + 3} = 51.1 \quad .$$

The average for the second year is then

$$\bar{y}_2 = \frac{41.6 + 39.9 + 51.1 + 43.3}{4} = 44.1 \quad ,$$

and the three-year average is

$$\bar{Y} = \frac{40.2 + 44.1 + 36.23}{3} = 40.2 \quad .$$

Following Appendix K conventions, the three-year average is rounded to 40, which is below the standard of 50 $\mu g/m^3$; thus attainment of the annual standard is shown.

Let us assume there were no observed PM 10 exceedances in the second year. Then, since the three substituted TSP values are all below the 24-hour PM 10 standard, the second year is estimated to have no exceedances. Since there were no observed exceedances in either the first or the third years, then the expected number of exceedances is estimated to be 0, and the 24-hour attainment test is passed.

EXAMPLE II: USE OF SUBSTITUTED PM 10 DATA FROM REPRESENTATIVE QUARTERS

Consider the same set of PM 10 observations as in Example I (see Table 1), except that no collocated TSP data are available. Thus, five substitutions must be made for the five scheduled PM 10 sampling days missing in the third quarter of the second year. Suppose it has been shown that emissions and meteorology of the quarter in question are typical for the third quarter in the three-year period and that data from nearby monitors support this. In this case data from other years can be substituted.

To estimate the mean for the third quarter, the maximum PM 10 concentration observed in the third quarter in the most recent three years is substituted for all five missing samples. Let us say this maximum is 96

$\mu g/m^3$. Then the third quarter average for the second year is calculated as

$$\bar{x}_3 = \frac{(11 \times 38.1) + (5 \times 96)}{11 + 5} = 56.2 \quad .$$

When averaged with the other quarterly averages of the second year, $\bar{y}_2$ is found to be 45.3 (using Appendix K rounding conventions), and the three-year average is thus 41 (rounded to the nearest integer) which is below the annual standard of 50 $\mu g/m^3$. Thus despite the substitution of five high 24-hour averages, attainment of the annual standard is still shown. With those substitutions, there are still no exceedances of the 24-hour standard.

EXAMPLE III: USE OF MODELING DATA

Consider again the same set of PM 10 observations of Example I (see Table 1). As in Example I, five scheduled sampling days of PM 10 data are missing but data are available from a collocated TSP monitor for three of those days. On these three days, the 24-hour average TSP concentrations are 97, 65, and 160 $\mu g/m^3$. If the concentration of 160 $\mu g/m^3$ were used as a substitute, there would be approximately six estimated exceedances for the quarter (using the calculations in Section 3 of Appendix K), and the site would not meet the standard. Although the two lower TSP concentrations combined with the 11 available PM 10 concentrations would meet Appendix K requirements of 12 samples per quarter, this is not a valid procedure, since one cannot selectively use TSP concentrations to meet the Appendix K requirements.

The site coordinator decides to use modeling data to estimate the number of exceedances and annual mean for the whole year. The EPA guidelines on the use of air quality models have been followed and the model is consistent with SIP guidelines. The model predicts that the maximum 24-hour average PM 10 concentration would have been 165 $\mu g/m^3$, and that the second-highest concentration for the year would have been 140 $\mu g/m^3$.

Thus, the model predicts one exceedance of the 24-hour standard for the second year. Since there were no observed exceedances in the first and third years, the expected annual number of exceedances is 0.3, and attainment of the 24-hour standard is demonstrated. The second-year annual average estimated by the model is 44.9 $\mu g/m^3$, which is consistent with the observed monitoring data. The three-year average is then

$$\bar{Y} = \frac{40.2 + 44.9 + 36.3}{3} = 40 \quad ,$$

which is below the expected annual average standard (50 $\mu g/m^3$).

EXAMPLE IV: COMBINED USE OF SUBSTITUTED PM 10 DATA AND MODELING DATA

In this example a site has only two years of sampling data available for a required sampling schedule of every day. The number of PM 10 samples in each quarter and the quarterly means and exceedance rates for the two years are shown in Table 2. Only 289 valid samples were collected the first year and 278 in the second year. The data capture rates for the first two quarters of the second year fall short of the 75 percent required by Appendix K. In each of the eight quarters, however, there are at least 45 samples (the minimum required by Section 2 of this guideline). In addition, there were no exceedances in the first year, and the mean concentration for that year is below the annual mean standard, so the site qualifies for the procedures of this guideline.

To demonstrate attainment, the site coordinator decides to substitute PM 10 data from representative quarters for the missing monitoring data in the two years, and then to use estimates derived from air quality models for the third year. Since the first two quarters of the second year have fewer than 68 days each (i.e., less than 75 percent data capture), substitutions must be made for all missing days in those quarters. Since emissions and meteorology in those quarters were similar to emissions and

TABLE 2. Quarterly PM 10 statistics and calculations for the two years in Example IV. All concentrations are in $\mu g/m^3$.

A. First year (no substitutions required).

Quarter	No. of Samples	Mean	Max. Conc.
1	68	42.6	84
2	75	47.8	67
3	77	52.1	126
4	69	45.1	72
Total	289		

Annual mean = (42.6 + 47.8 + 52.1 + 45.1)/4 = 46.9

B. Second year (substitutions required for first two quarters).

Quarter	No. of Samples	Observed Mean	Max. Conc.	Substitute Conc.	No. of Substitutes	Estimated Mean
1	53	44.8	72	84	37	60.9
2	66	39.6	69	69	22	45.4
3	82	61.3	165			61.3
4	77	43.1	77			43.1
Total	278					

Estimated annual mean = (60.9 + 45.4 + 61.3 + 43.1)/4 = 52.7

meteorology in the first two quarters of the first year, the site coordinator chooses to fill in the missing days with the maximum concentrations observed in the quarters over both years. The highest 24-hour PM 10 concentration in the first quarter of both years was 84 $\mu g/m^3$; for the next quarter the maximum over both years was 69 $\mu g/m^3$. These two values are substituted appropriately for each of the missing days in the first two quarters of the second year. The means calculated from the monitored and substituted concentrations are given in Table 2; the estimated annual means are 46.9 and 52.7 $\mu g/m^3$ (using Appendix K round-off conventions).

In the two years of monitoring data there was only one exceedance of the 24-hour PM 10 standard; a concentration of 165 $\mu g/m^3$ was obtained in the third quarter of the second year. For that quarter, however, there were 10 scheduled sampling days with missing data, and so the number of exceedances must be estimated. Using the calculations in Section 3 of Appendix K, the estimated number of exceedances for the quarter is 1.1, and the total estimated number of exceedances for the second year is therefore also 1.1 (since there are no exceedances in the other three quarters).

Modeling data are used to estimate the number of exceedances and annual mean for the third year. The EPA guidelines on the use of air quality models have been followed and the model is consistent with SIP guidance. The model predicts one exceedance of the 24-hour PM 10 standard in the third year and an annual average PM 10 concentration of 47.3 $\mu g/m^3$ for the year.

The expected annual concentration is then calculated as the average of 46.9 $\mu g/m^3$ (observed in the first year), 52.7 $\mu g/m^3$ (estimated after substitutions for the second year), and 47.3 $\mu g/m^3$ (predicted by the model for the third year). The three-year average (rounded to the nearest integer) is 49 $\mu g/m^3$, which is below the standard of 50 $\mu g/m^3$. In a similar fashion, the expected annual number of exceedances is calculated as the average of 0 (observed in the first year), 1.1 (estimated for the second year), and 1 (predicted by the model for the third year). The three-year average, rounded to one decimal place, is 0.7, so the site is in attainment of both the annual and the 24-hour standard.

Section 5

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